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DOSE-DEPENDENT EFFECTS OF DIETARY *HIBISCUS SABDARIFFA* POWDER ON GROWTH PERFORMANCE AND PHENOTYPIC CORRELATIONS AMONG PRODUCTIVE TRAITS IN BROILER CHICKENS

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ABSTRACT

This study was conducted to investigate the influence of dietary *Hibiscus sabdariffa* powder supplementation on the growth performance of Ross 308 broiler chickens. A total of 120 day-old broiler chicks were randomly assigned to four experimental groups that received diets supplemented with 0.0, 0.5, 1.0, or 1.5% *H. sabdariffa* powder. Each treatment consisted of three replicates with 10 birds per replicate, and the feeding trial lasted for 35 days. Growth performance was assessed by measuring initial body weight (IBW), final body weight (FBW), daily feed intake (DFI), and feed conversion ratio (FCR). The collected data were subjected to one-way analysis of variance (ANOVA), while Pearson's correlation analysis was performed to examine the associations among the measured growth performance parameters. No significant differences were observed in initial body weight (IBW) among the experimental treatments (P>0.05), indicating uniformity of the chicks at the start of the trial. In contrast, dietary inclusion of *Hibiscus sabdariffa* significantly enhanced both FBW (P=0.0092) and FCR (P<0.0001). Birds receiving 1.0 and 1.5% supplementation achieved the highest FBW values (1990.7 and 1992.0 g, respectively), compared with 1750.0 g in the control group. The best feed conversion ratio was observed in birds fed 1.0% H. sabdariffa (1.53), representing an improvement of approximately 22.7% over the control group (1.98). A significant effect of dietary treatment on daily feed intake (DFI) was observed (P=0.0508), with improved growth performance occurring without a corresponding increase in feed consumption. Correlation analyses indicated that enhanced body weight was associated with improved feed efficiency rather than increased feed intake. Dose–response evaluation further demonstrated that productive performance improved progressively up to 1.0% supplementation, after which no substantial additional benefits were observed. In conclusion, dietary inclusion of 1.0% *Hibiscus sabdariffa* powder improved growth performance and feed utilization efficiency in broiler chickens and may serve as a promising natural phytogenic feed additive for poultry production.

Keywords: *Hibiscus sabdariffa*, Broiler chickens, Growth performance, Correlation coefficients, Phytogenic feed additive, Anthocyanins.

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1. INTRODUCTION

The poultry industry has increasingly adopted natural feed additives as sustainable alternatives to antibiotic growth promoters in response to growing concerns regarding antimicrobial resistance and the rising consumer demand for naturally produced poultry products (Ayalew et al., 2022). Consequently, phytogenic feed additives derived from medicinal and aromatic plants have attracted considerable attention due to their potential to improve growth performance, health status, and production efficiency while supporting environmentally sustainable poultry production systems (Al Salman & Al-Gharawi, 2019).

Among the numerous phytogenic resources currently under investigation, *Hibiscus sabdariffa* L. (roselle), a member of the Malvaceae family, has emerged as a promising natural feed additive. Roselle has long been utilized as a medicinal and aromatic plant in traditional foods, herbal beverages and pharmaceutical preparations. Beyond its nutritional composition, *Hibiscus sabdariffa* exhibits numerous biological activities. Its bioactive constituents have been reported to exert potent antioxidant, antimicrobial, antihypertensive, hypolipidemic, antidiabetic, hepatoprotective, nephroprotective, and anti-inflammatory effects (Da-Costa-Rocha et al., 2014). These beneficial effects have largely been attributed to its rich phytochemical composition, which includes anthocyanins, flavonoids, phenolic acids, organic acids, vitamin C and other bioactive compounds (Sultan & Khorsheed, 2018; Gantner et al., 2025).

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Anthocyanins represent one of the most biologically important constituents of roselle. These water-soluble flavonoid pigments are responsible for the characteristic red coloration of roselle calyces and have attracted considerable interest because of their diverse physiological functions. Numerous studies have demonstrated that anthocyanins possess potent antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory activities (Khoo et al., 2017). In both humans and animals, anthocyanins have been reported to reduce oxidative stress, improve glucose and lipid metabolism, support cardiovascular function, enhance immune responses, and protect tissues against free radical-induced damage (Prior et al., 2008; Varga et al., 2013; Mrkvicová et al., 2017). Furthermore, these compounds contribute to the regulation of antioxidant defense systems and may reduce the risk o/f several oxidative stress-related disorders (Kamboh et al., 2015).

In recent years, increasing attention has been directed toward the use of anthocyanin-rich plant materials as natural growth-promoting agents in livestock and poultry production. Several studies have demonstrated beneficial effects of dietary anthocyanins on animal performance, health status, and product quality (Kowalczyk et al., 2003; Kim & Park, 2006; Xia et al., 2006; Yilmaz, 2019). The beneficial effects of *Hibiscus sabdariffa* are thought to be mediated, in part, through its ability to regulate the gut microbial ecosystem. Anthocyanin-rich phytochemicals enhance intestinal barrier integrity, favor the establishment of beneficial bacteria such as *Lactobacillus* spp. and *Bifidobacterium* spp., and limit the growth of pathogenic microorganisms. Consequently, these microbial and intestinal adaptations improve nutrient availability, digestive efficiency, and overall gut health (Boto-Ordóñez et al., 2014; Anhê et al., 2015; Ma et al., 2019).

The biological properties of roselle make it particularly attractive for poultry nutrition. Previous reports have suggested that *Hibiscus sabdariffa* may improve digestive function, enhance nutrient utilization, stimulate blood circulation, strengthen immune responses, and alleviate the adverse effects of environmental stressors, particularly heat stress (Nasrawi, 2013; Al-Gharawi et al., 2014). Moreover, the antioxidant activity of roselle-derived phytochemicals may protect intestinal tissues against oxidative damage and contribute to improved physiological performance in broiler chickens (Al-Kennany & Al-Khafaf, 2010; Yuliastri et al., 2021).

Although the use of Hibiscus sabdariffa in poultry diets has received increasing scientific attention in recent years, previous studies have reported inconsistent findings on the optimal dietary inclusion level. Parfait et al. (2024) and Maggawa et al. (2020) observed improved body weight gain when roselle was incorporated at 2.0 and 2.5% of the diet, respectively. However, excessive dietary supplementation (>4%) impaired productive performance, as reflected by reduced feed intake, diminished body weight gain, and less efficient feed conversion. Similarly, Nasrawi (2013) reported the highest body weight at a dietary inclusion level of 1%, whereas Amer et al. (2022) observed no significant improvement in growth performance when roselle extract was supplemented at relatively low concentrations (50–400 mg/kg diet). Furthermore, Mohammed et al. (2022) demonstrated that excessive roselle supplementation (5–15% of the diet) negatively affected growth performance compared with unsupplemented birds. These contrasting findings indicate that the productive response to *Hibiscus sabdariffa* supplementation is dose-dependent and emphasize the importance of identifying an optimal dietary inclusion level.

Therefore, the present study was conducted to evaluate the effects of graded dietary levels of *Hibiscus sabdariffa* powder on growth performance traits of Ross 308 broiler chickens. In addition, phenotypic correlations among selected performance traits were investigated to provide further insight into the biological relationships associated with roselle supplementation and to identify its potential as a natural phytogenic feed additive in broiler production.

2. MATERIALS AND METHODS

2.1. Experimental Design and Bird Management

This experiment was conducted at the Experimental Animal Research Station, King Faisal University, Saudi Arabia, to investigate the effects of dietary *Hibiscus sabdariffa* powder on the growth performance of broiler chickens. A total of 120 one-day-old Ross 308 broiler chicks were procured from a commercial hatchery and raised under standard management conditions for 35 days. At the beginning of the trial, each chick was individually weighed before being randomly assigned to one of four dietary treatment groups, with 30 birds per treatment. Each treatment comprised three replicate pens containing 10 birds each, and the replicate pen served as the experimental unit for subsequent statistical analyses.

Experimental diets were formulated to meet or exceed the nutrient requirements recommended for broiler chickens. Four dietary treatments were prepared by supplementing a basal diet with *Hibiscus sabdariffa* powder at inclusion levels of 0.0, 0.5, 1.0, and 1.5%. The roselle powder was thoroughly mixed with the basal diet before feeding to ensure uniform distribution. Birds were housed in floor pens (16 ft^2 per pen) under identical management and environmental conditions throughout the experimental period. Wood shavings were used as litter material, and adequate ventilation was maintained in all pens. Feed and fresh drinking water were provided ad libitum throughout the trial. During the first week, the environmental temperature was maintained at 32–34°C and subsequently

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decreased by approximately 2–3°C per week until it stabilized at 22–24°C for the remainder of the experimental period. Relative humidity was maintained at 60–70% throughout the experimental period. A photoperiod of 23 h of light and 1 h of darkness was provided during the first week, after which the lighting program was adjusted to 20 h of light and 4 h of darkness for the remainder of the 35-day trial. All birds were vaccinated according to standard commercial broiler management practices.

2.2. Growth Performance Measurements

Body weight (BW) of individual birds was recorded weekly using a digital balance with gram accuracy. Final body weight (FBW) was recorded at 35 days of age. Body weight gain (BWG) was calculated as the difference between the final and initial body weights during the experimental period. Feed intake (FI) was determined weekly by subtracting the amount of feed remaining in the feeders from the total quantity of feed offered. Feed residues were collected and weighed before each measurement to ensure accurate estimation of feed consumption. Daily feed intake (DFI) was subsequently calculated for each replicate. Feed conversion ratio (FCR) was calculated according to the following equation:

$$FCR = \text{Feed Intake (g)} / \text{Body Weight Gain (g)}$$

Growth performance variables evaluated in the present study included initial body weight (IBW), final body weight (FBW), daily feed intake (DFI), and feed conversion ratio (FCR).

2.3. Correlation Analysis

To investigate the relationships among growth performance parameters, Pearson's correlation coefficients were determined using data collected at 35 days of age. The analysis was based on four performance indicators: initial body weight (IBW), final body weight (FBW), daily feed intake (DFI), and feed conversion ratio (FCR). Correlation coefficients (r) and their associated p-values were used to assess the strength and direction of relationships among the traits studied and to provide further insight into the biological responses associated with dietary *Hibiscus sabdariffa* supplementation.

2.4. Statistical Analysis

The experimental data were statistically analyzed using the General Linear Model (GLM) procedure of SAS software (SAS Institute, 2004). Treatment effects on growth performance variables were evaluated by one-way analysis of variance (ANOVA) according to the following statistical model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where Y_{ij} represents the observed value of the dependent variable, (μ) is the overall mean, (T_i) denotes the fixed effect of the *i*th dietary treatment, and (e_{ij}) is the random residual error. Whenever the ANOVA indicated significant treatment effects, differences among treatment means were compared using Duncan's Multiple Range Test, with statistical significance declared at $P<0.05$.

Descriptive statistics were calculated, and data are presented as means ± standard error (SE). In addition, Pearson correlation analyses were performed using SAS's CORR procedure to evaluate associations among IBW, FBW, DFI, and FCR measured at 35 days of age. Correlation coefficients were interpreted according to both their magnitude and statistical significance.

3. RESULTS AND DISCUSSION

3.1. Effect of Dietary *Hibiscus sabdariffa* on Growth Performance

The effects of dietary supplementation with graded levels of *Hibiscus sabdariffa* powder on growth performance traits of Ross 308 broiler chickens are presented in Table 1 and Fig. 1. No significant differences were detected among experimental groups for initial body weight (IBW) (P=0.3700), indicating a satisfactory degree of homogeneity among chicks before the initiation of dietary treatments. This confirms that subsequent differences observed in productive performance were primarily attributable to dietary supplementation rather than initial variation among birds. In contrast, final body weight (FBW) was significantly influenced by dietary *H. sabdariffa* supplementation (P=0.0092). Broilers receiving 1.0 and 1.5% roselle powder achieved the highest FBW values (1990.7 and 1992.0 g, respectively), whereas the control and 0.5% groups recorded significantly lower weights (Fig. 1A). Compared with the control treatment, birds fed 1.0% roselle exhibited an approximately 13.8% increase in final body weight.

Table 1: Influence of different levels of *Hibiscus sabdariffa* on Growth performance of broilers at 5 weeks of age

Trait	Treatments (*Hibiscus sabdariffa*)				Probability
	Control	0.5%	1%	1.5%	
Initial body weight, g	41.3 ± 0.8	42.6 ± 0.3	42.3 ± 0.3	42.3 ± 0.3	0.3700
Final body weight, g	1750 ± 61.61b	1793.0 ± 67.57b	1990.7 ± 3.84a	1992.0 ± 5.03a	0.0092
Daily feed intake, g at 5 weeks	113.8 ± 5.43b	124.7 ± 2.33a	112.3 ± 1.76b	115.8 ± 1.30ab	0.0508
Feed conversion ratio	1.98 ± 0.04a	1.94 ± 0.02a	1.53 ± 0.01c	1.81 ± 0.03b	0.0001

Values (Mean ± SD) within the same row with different letters differ significantly.

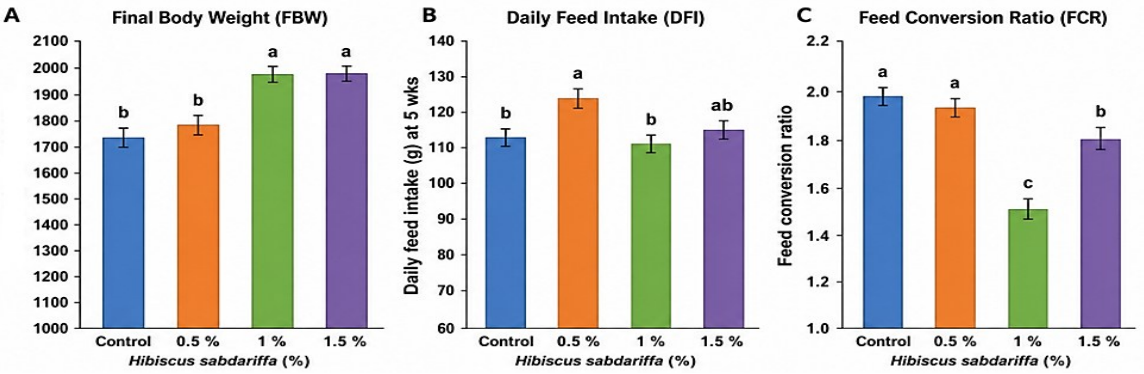

Fig. 1: Effect of dietary Hibiscus sabdariffa supplementation on final body weight (FBW), daily feed intake (DFI), and feed conversion ratio (FCR) of broiler chickens at 35 days of age. Bars represent mean ± SE. Different letters above bars indicate significant differences among treatments (P<0.05).

The dose-response relationship illustrated in Fig. 2 further demonstrates a progressive increase in FBW as dietary roselle levels increased from 0 to 1.0%, followed by a plateau response between 1.0 and 1.5%. This pattern suggests that the optimal biological response was achieved at approximately 1.0% inclusion, beyond which additional supplementation did not result in further growth enhancement. The improvement in body weight may be attributed to the rich phytochemical profile of roselle. *Hibiscus sabdariffa* contains substantial concentrations of anthocyanins, flavonoids, phenolic acids, protocatechuic acid, vitamin C and various organic acids. These bioactive constituents possess potent antioxidant, antimicrobial, and anti-inflammatory activities that contribute to maintaining intestinal integrity, enhancing nutrient digestion and absorption, modulating gut microbiota, and protecting intestinal tissues against oxidative stress, thereby improving growth performance and feed utilization in poultry (Jiang et al., 2023; Abd El-Hack et al., 2023; Obianwuna et al., 2024).

Da-Costa-Rocha et al. (2014) reported that roselle is particularly rich in anthocyanins and phenolic compounds responsible for numerous biological activities, including antioxidant and antimicrobial effects that may contribute to improved nutrient utilization. Likewise, Amer et al. (2022) demonstrated that anthocyanin-rich roselle extract improved intestinal histomorphology and antioxidant status in broilers, which may explain the enhanced growth performance observed in the present study. Furthermore, Nasrawi (2013) reported significant improvements in body weight and body weight gain in broilers supplemented with roselle flower powder, supporting the findings obtained herein.

Daily feed intake (DFI) was significantly affected by dietary treatment (P=0.0508). The highest feed intake was observed in birds receiving 0.5% roselle supplementation, whereas broilers fed 1.0% roselle consumed less feed and achieved the greatest final body weight (Fig. 1B).

The relationship between FBW and DFI shown in Fig. 3 provides further evidence that improved growth performance was not associated with increased feed consumption. Instead, birds achieving superior body weight required relatively lower feed intake, suggesting enhanced digestive efficiency and nutrient utilization. This observation is particularly important because it indicates that roselle acted primarily by improving biological efficiency rather than stimulating appetite. Several mechanisms may explain this response. Organic acids naturally present in roselle can reduce gastrointestinal pH, stimulate digestive enzyme activity, and improve nutrient digestibility, whereas polyphenolic compounds, including anthocyanins and flavonoids, positively modulate the intestinal microbiota, reinforce gut barrier function, and alleviate oxidative stress. Collectively, these physiological effects enhance nutrient utilization and feed efficiency, thereby promoting improved growth performance in poultry (Obianwuna et al., 2024; Abd El-Hack et al., 2023). Previous studies have shown that anthocyanins can stimulate beneficial bacterial populations, including *Lactobacillus* spp. and *Bifidobacterium* spp., while suppressing pathogenic microorganisms, thereby improving nutrient availability and gut health (Boto-Ordóñez et al., 2014; Ma et al., 2019; Kapoor et al., 2023; Liang et al., 2024; Obianwuna et al., 2024).

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Feed conversion ratio (FCR) was the trait most strongly affected by dietary supplementation (P<0.0001). Birds receiving 1.0% roselle exhibited the best feed conversion efficiency (1.53), followed by the 1.5% treatment (1.81), whereas the control group showed the poorest efficiency (1.98) (Fig. 1C).

The magnitude of improvement observed in FCR is particularly noteworthy from both biological and economic perspectives. Relative improvement analysis (Fig. 5) revealed that supplementation with 1.0% roselle improved feed efficiency by approximately 22.7% compared with the control group. Such improvement indicates that birds were able to convert feed nutrients into body tissue more efficiently. Ali (2026) indicated that adding extract of hibiscus powder improved the productive performance of the broiler chickens aged 7-35 days compared to the other treatments.

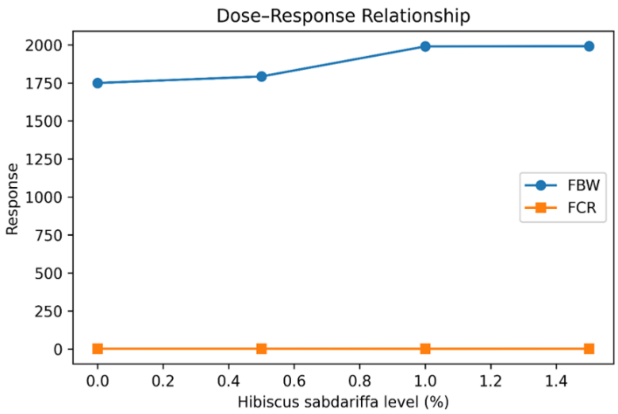

Fig. 2: Effect of increasing dietary *Hibiscus sabdariffa* levels on final body weight of broiler chickens

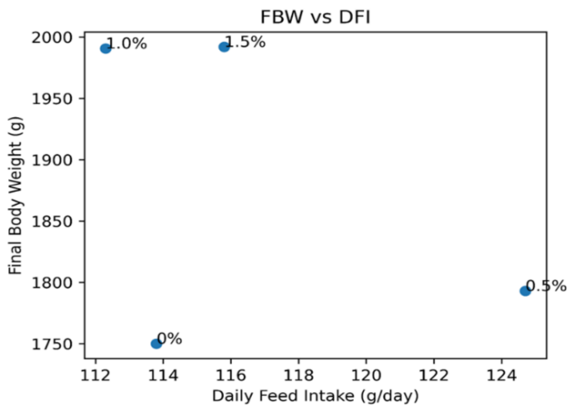

Fig. 3: Relationship between final body weight (FBW) and daily feed intake (DFI) in broiler chickens fed *Hibiscus sabdariffa*.

The dose-response curve (Fig. 2) clearly demonstrates that FCR decreased substantially as roselle inclusion increased up to 1.0%, after which a slight decline in response occurred at 1.5%. This trend reinforces the conclusion that 1.0% represents the optimal dietary inclusion level under the conditions of the present.

The relationship between FBW and FCR presented in Fig. 4 revealed a strong inverse association, whereby higher final body weights were consistently accompanied by lower FCR values. This finding confirms that the heavier birds were also the most feed-efficient, emphasizing the biological effectiveness of roselle supplementation, which is consistent with recent reports demonstrating that phytobiotic and roselle-based dietary supplements improve body weight gain and feed conversion efficiency in broiler chickens (Ayssiwede et al., 2023; Chongtham et al., 2023; Biswas et al., 2024). The marked improvement in feed conversion ratio may result from multiple complementary mechanisms. Anthocyanins and other phenolic compounds possess potent antioxidant and anti-inflammatory activities that protect intestinal epithelial cells against oxidative damage, preserve intestinal barrier integrity, enhance nutrient absorption, and improve digestive efficiency. These physiological benefits ultimately contribute to improved feed utilization and growth performance in poultry (Abd El-Hack et al., 2023; Jiang et al., 2023; Obianwuna et al., 2024; Liang et al., 2024).

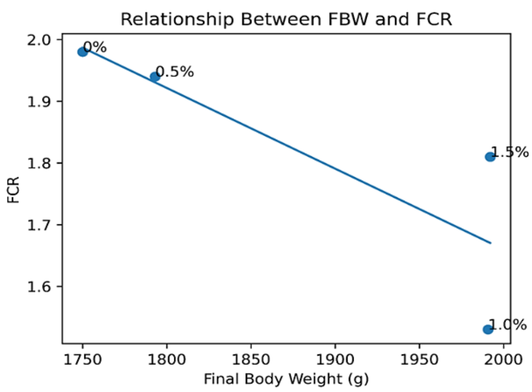

Fig. 4: Relationship between final body weight (FBW) and feed conversion ratio (FCR) in broiler chickens fed *Hibiscus sabdariffa*.

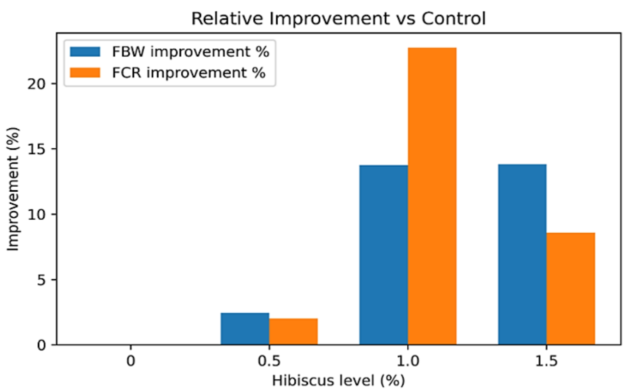

Fig. 5: Relative Improvement analysis (%) Compared with Control treatment.

Improved intestinal morphology, including increased villus height and absorptive surface area, has been reported in broilers receiving roselle extracts (Amer et al., 2022). Enhanced intestinal functionality increases nutrient absorption efficiency and consequently improves feed conversion.

Additionally, the antimicrobial activity of roselle polyphenols may reduce the abundance of pathogenic bacteria in the gastrointestinal tract. Lower microbial competition for nutrients allows a greater proportion of dietary nutrients to be utilized by the host animal, thereby improving productive efficiency. Similar mechanisms have been proposed for other phytogenic feed additives used in poultry nutrition (Windisch et al., 2008; Hashemi and Davoodi, 2011; Wang et al., 2024; Biswas et al., 2024; Obianwuna et al., 2024; Bashir et al., 2025).

3.2 Correlation Analysis

Pearson correlation coefficients among growth traits revealed several biologically meaningful relationships are shown in Table 2. In the 0.5% treatment, the strong positive association between IBW and FCR (r=0.961) indicates that heavier chicks at placement tended to exhibit higher feed conversion values. Conversely, the negative correlations between FBW and both DFI and FCR suggest that birds achieving greater final body weight generally utilized feed more efficiently. Within the 1.0% treatment, the strong negative correlations of IBW with DFI (r=−0.945) and FCR (r=−0.988) indicate that birds with greater initial body weight required less feed and exhibited superior feed efficiency. These relationships are consistent with the overall performance results and further support the hypothesis that the 1.0% inclusion level optimized nutrient utilization. In the 1.5% treatment, the significant negative relationship between IBW and DFI (r=−0.896, P<0.05) suggests that heavier birds consumed less feed while maintaining growth performance. This pattern may indicate improved metabolic efficiency and more effective nutrient partitioning.

The correlation heatmap (Fig. 6) provides a comprehensive visualization of the relationships among growth performance traits. Final body weight exhibited a strong negative association with feed conversion ratio, indicating that birds with greater body weight tended to utilize feed more efficiently. Conversely, feed intake displayed a weaker relationship with final body weight, further supporting the conclusion that improvements in growth performance were primarily associated with enhanced nutrient utilization rather than increased feed consumption.

Table 2: Pearson correlation coefficients among initial body weight (IBW), final body weight (FBW), daily feed intake (DFI), and feed conversion (FC) of broilers fed different dietary levels of *Hibiscus sabdariffa*

Traits	IBW	FBW	DFI	FC
		T1 (0.5%) *Hibiscus sabdariffa*		
IBW	1	-0.79172	0.14286	0.96077
		0.4184	0.9087	0.1789
FBW		1	-0.71772	-0.59123
			0.4904	0.5973
DFI			1	-0.13725
				0.9123
FC				1
		T2 (1%) *Hibiscus sabdariffa*		
IBW	1	0.43355	-0.94491	-0.98783
		0.7145	0.2123	0.0994
FBW		1	-0.11471	-0.56844
			0.9268	0.6151
DFI			1	0.88250
				0.3117
FC				1
		T3 (1.5%) *Hibiscus sabdariffa*		
IBW	1	0.39736	-0.89608*	0.50000
		0.7399	0.0564	0.6667
FBW		1	-0.47699	0.89340
			0.6835	0.0732
DFI			1	-0.57466
				0.6103
FC				1

* P<0.05; IBW=Initial body weight, FBW=Final body weight; DFI=Daily feed intake, FC=Feed conversion.

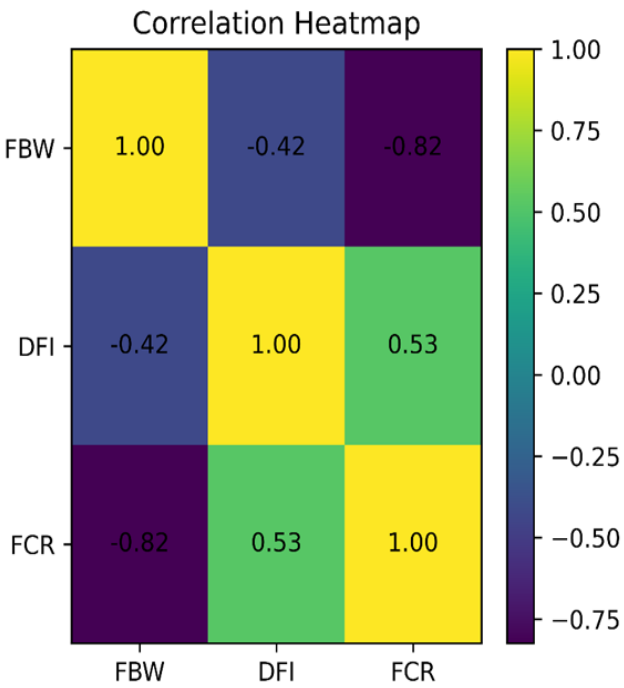

Fig. 6: Correlation Heatmap of the relationships among growth performance traits.

These findings are consistent with the scatterplot analyses presented in Fig. 3 and 4, which collectively demonstrate that dietary roselle supplementation improved biological efficiency by increasing body weight while simultaneously reducing feed required per unit of gain. Therefore, the productive benefits of *Hibiscus sabdariffa* appear to be mediated through improvements in digestive efficiency, antioxidant status, intestinal functionality, and nutrient utilization.

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4. CONCLUSION

The present study demonstrated that dietary supplementation with *Hibiscus sabdariffa* powder positively influenced the growth performance of Ross 308 broiler chickens. Birds receiving 1.0 and 1.5% roselle supplementation exhibited significantly greater final body weight than the control group, while the most favorable feed conversion ratio was achieved at the 1.0% inclusion level. The dose–response analysis further revealed that productive performance improved progressively up to 1.0% supplementation, after which no substantial additional benefits were observed, indicating a plateau response. The improved growth performance and feed efficiency observed in roselle-supplemented birds are likely associated with the bioactive constituents of *H. sabdariffa*, particularly anthocyanins, flavonoids, and phenolic compounds, which may enhance intestinal functionality, antioxidant status, and nutrient utilization efficiency. Correlation analyses further supported that the observed improvements were primarily related to enhanced feed utilization rather than increased feed consumption.

Overall, the findings suggest that dietary inclusion of 1.0% *Hibiscus sabdariffa* powder represents the optimal supplementation level under the conditions of the present study and may serve as a promising natural phytogenic feed additive for improving broiler productivity. Further investigations are warranted to elucidate its effects on carcass characteristics, gut microbiota, immune responses, blood biochemical indices, and meat quality.

Declarations

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Conflicts of Interest: No conflicts of interest were encountered in the paper.

Data Availability: The data that support the findings of this study are available in the material of this article. There is no other supporting data.

Ethics Statement: All animal-conducted investigational processes were approved by the Research Ethics Committee of King Faisal University, Saudi Arabia (KFU-2026-ETHICS4351).

Author's Contributions: All authors contributed equally to the investigation and preparation of the present study. All authors discussed the results and commented on the manuscript.

Generative AI Statements: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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